DIGITALISATION IN THE UK MARITIME SECTOR: A STAKEHOLDERS' PULSE CHECK

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SUMMARY

Several digitalisation technologies have recently emerged, reshaping organisations across various industries and sectors. Such technologies, commonly placed under the Industry 4.0 (I4.0) umbrella term, include Internet of Things (IoT), cloud computing, blockchain, and Artificial Intelligence (AI). They aim to enable data collection, exchange, processing, and automation to support a system to make decisions autonomously. This paper presents the Intelligent Naval 4.0 project (IN 4.0), aiming to ease the adaptation and adoption of I4.0 practices and technologies in maritime sector companies in order to improve their competitiveness. This will be achieved through a four-pronged approach aiming to: analyse the current state-of-art as applied to other industries; define a protocol for the redefinition of workers' tasks; investigate cost-reduction methods for the implementation of 4.0 technologies; and counsel businesses for the transformation of maritime SMEs to the 4.0 era. Special focus will be given to the training required to get workers acquainted with new technologies and remain competitive in this changing labour market. Recent progress and advances of the IN 4.0 project along with future plans are presented and discussed, thus revealing the expected future transformation of the maritime industry.

1. INTRODUCTION

Ships are a crucial asset of the global goods transportation system, as 85% of merchandise is carried by sea (Clarkson PLC, 2018). However, the shipping industry has remained change-averse for a long time, only adopting new technologies when required by regulations or when a short-term financial benefit is evident.

Many other industries are rapidly changing, incorporating I4.0 practices and technologies stemming. Such technologies include Internet of Things (IoT), cloud computing, blockchain, and Artificial Intelligence (AI). The aim of I4.0 is to enable data collection, exchange, processing, and automation to support systems to make decisions autonomously.

These new technologies are trickling down to the shipping industry. Nonetheless, these changes often only affect the state-of-art, leaving the state-of-practice stationary. Furthermore, even when changes reach the state-of-practice (e.g. Inmarsat reports that the average surveyed ship-owning organisation plans to invest $2.5 million in IoT applications over the next 3 years (Inmarsat, 2018)), these are often only applied lackadaisically, leading to lacklustre results that, in turn, hinder future R&D investments.

This paper aims to present the IN 4.0 project, aiming to ease the adaptation and adoption of I4.0 practices and technologies in maritime sector companies in order to improve their competitiveness. More specifically, the project aims to promote the modernisation of the maritime sector through the implementation of actions that help to transform Small-Medium Enterprises (SMEs) to their 4.0 equivalents, identifying barriers that prevent the innovation of the maritime sector business model, improving the companies' production processes, transforming the work organisation systems, knowledge and commercialisation, as well as training workers of the maritime sector in new occupations and tasks.

2. BACKGROUND

The maritime sector occupies a central position in the growth of many countries' economies, being deeply rooted in the Atlantic Area countries and presenting a common problem: the urgency of getting contracts in a very competitive market, mainly caused by very low labour costs in European countries such as Romania, Turkey, Poland or Croatia, or at worldwide level such as Asian, competing with the maritime companies of the Atlantic Area countries. To prevent a competitive disadvantage of the Atlantic Area maritime sector based on the reduction of wages, and considering the particularities of the small size of the sector companies, the joint solution to be applied must be based on technological improvements associated to the new paradigm, supported by innovations such as optimised organisation or others, linked to training and commercialisation.

The above remarks solidify the need for a collaboration between industry and academia in order to sustain and improve the competitiveness of the UK maritime industry. The innovative character of the project stems firstly from its own nature, because it addresses the issue of innovation in the shipbuilding industry by adapting its business model towards Industry 4.0. So far, the innovation has been oriented to achieve greater efficiency in the production process. However, the shipbuilding sector SMEs cannot implement the technologies required to adapt their business model without having a skilled workforce, an organisational structure adapted to the 4.0 industry processes, suitable marketing channels, a pre-selection of existing technologies and their degree of maturity, or the

tools to reduce implementation costs in their workplaces. In this sense, IN 4.0 is an innovative project, aiming to boost the maritime sector, through the efficient use of human talent based on organisational innovation (creation of new functions / tasks of different jobs for an effective implementation of each one of the detected technologies), the design of a specific training model (that fulfils the training needs of the naval sector workforce in the context of factory 4.0: managers, middle managers, including graduates) and the definition of new marketing methods. Furthermore, all the above will be implemented in and demonstrated through 10 SMEs selected among beneficiary countries of INTERREG Atlantic Area Programme.

3. IN 4.0 FRAMEWORK

The IN 4.0 project aims to improve the competitiveness of naval sector companies through the adaptation of the traditional productive model towards Industry 4.0, guaranteeing the sector's endurance in an increasingly demanding market where technological innovation is a key factor of strategic advantage.

To achieve this goal, the main barriers which impede the adaptation of the naval sector business model will be validated; determining the degree of maturation of existing technologies that could be implemented in naval SMEs; redefining work organisation systems; qualifying naval sector workers in order to move towards a 4.0 model; designing innovative strategies to save costs in the implementation of technologies, detecting new marketing methods and implementing the innovations designed under IN 4.0 in the selected SMEs of the participating regions in the project.

It is implemented through 4 technical work packages:

1. IN CONTEXT: starting point towards the adaptation of a new productive model 4.0 on the basis of the existing state of the art, detection of innovation applicable to the important 4.0 naval technologies relevant for the naval sector.
2. IN WORK AND IN TRAINING: Protocol for the redefinition of workers' tasks and training of sector staff.
3. IN COMMERCIALISATION AND COSTS: Reduction of the costs related to the implementation of technologies, and new methods of commercialisation.
4. IN ADAPTATION: Counselling for the transformation of naval companies into intelligent companies.

4. IN 4.0 PROGRESS & ADVANCES

As part of the IN 4.0 project, an event was held in Glasgow to determine the current state of the UK Maritime Sector and introduce the concept of I4.0 to relevant stakeholders, namely technology providers, industry, funding bodies and academics.

In order to achieve the goals of this event, attendants were asked to participate in a number of digital surveys to gauge their opinions on various topics. Furthermore, following the completion of each survey, each group of attendants was given 5 minutes to discuss the question in further detail with an aim of gathering key points and establishing commonalities across the industry. Some of the key topics discussed are presented below.

4.1 LEVEL OF I4.0 ADOPTION

As shown in Figure 1, the survey showed distinct variance across the results with the majority of attendees at least scoping potential I4.0 implementation. It was noted that an additional choice of "Not ready yet" would have been more applicable with the current position of a number of businesses.

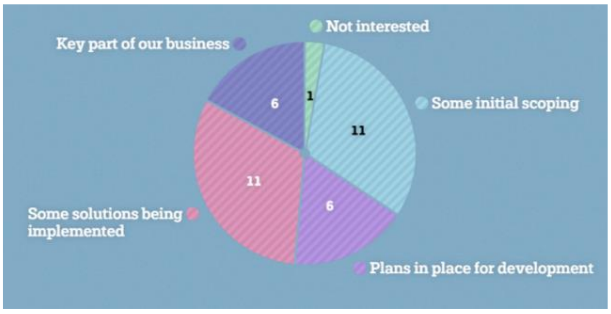

Figure 1: Survey results obtained on "Where do you feel your business is currently positioned on its I4.0 journey" question.

Some of the key points of the conversation that ensued are summarised below:

- Lack of strong Leadership to drive forward innovative projects leading to unsuccessful implementation and disengagement.
- The industry is difficult to compare to others due to the inability to prototype, long lead times, and ship building operations commencing prior to complete vessel design.
- General consensus that the maritime sector is extremely risk adverse leading to a lack of willingness for developing new and innovative solutions.
- There is no clear technology strategy across many businesses in the sector.
- Concerns over an aging workforce who may not be technically adept but possess extensive knowledge which could soon be lost to future generations in the industry.
- There is a lack of knowledge on the technologies within I4.0 and the potential benefits to the business as well as a strategy to develop solutions.
- Bureaucratic procedures can become a challenge when implementing a new technology. It was recognised that the level of technology adoption within the UK maritime sector is lagging

compared to other nations making it very difficult to compete.
- Cost is critical to the sector resulting in a reluctance to invest.
- Connectivity presents a major barrier to new and emerging technology – very few industrial sites have WiFi compared to other manufacturing industries where it is standard.

Furthermore, a major factor which is influencing the adoption of I4.0 appears to be a lack of understanding regarding the technology and its benefits. Businesses should take the time to research the different options that are now available and used in other industries. This could be in the form of benchmarking activities, higher education courses, conferences etc. This should be undertaken across all functions and include all levels of employees to ensure engagement across the business. In order to train future generations, it is key that efforts are made to capture as much existing knowledge as possible before the aging workforce retires.

4.2 KEY TECHNOLOGIES

As displayed in Figure 2, whilst the most popular result was automation, there is also a clear realisation that the amount of data available is going to dramatically increase through better connectivity and condition monitoring. There was also clear concern over the security of this data and who could potentially gain access to it. This is likely to cause issues both in terms of implementation and effective utilisation of this data.

Figure 2: Survey results obtained on "What technologies do you see having the largest impact on the maritime industry in the UK" question.

Some of the key points of the conversation that followed are presented next:
- It is widely accepted that connectivity is key to the future of the maritime industry, but also that the sector is significantly behind other manufacturing sectors in terms of infrastructure.
- Digitisation is key to helping ensure profitability for the industry by allowing for increased design maturity, risk mitigation and training solutions prior to any physical building operation.
- Adoption of automation is seen as a major focus – There is a perception that the UK is lagging behind with respect to other countries.
- Communication is poor, and businesses rarely collaborate with one another resulting in siloed businesses – many other industries have become much more open to greater collaboration through digital means.
- Additive manufacturing is seen as having an important role to play in particular for retrofitting and repairing aging vessels.

Data is going to play a major role in the future of the sector, however caution is advised to avoid potential data overload. This could lead to misinterpretation and potentially poor strategic decisions. Businesses should begin setting out a clear and well-defined plan looking at least 5 years into the future to successfully scope what data is required, how it can be accessed, processed and how to present it. A similar approach would also be recommended for implementing automated solutions to assess the potential applications and to highlight benefits. These tasks are not likely to form a part of day to day business for many in the sector, and the job roles involved are often highly skilled and expensive, making recruitment difficult. Businesses could also consider subcontracting these skills externally for the early stages of the implementation.

4.3 KEY DRIVERS FOR I4.0 ADOPTION IN THE BUSINESS

As shown in Figure 3, in most businesses, cost is the main reason for looking into new technologies and processes. There is a clear realisation that the sector must adapt to compete with potentially cheaper alternatives around the globe.

Figure 3**:** Survey results obtained on "What do you believe is the key driver for your business to embrace I4.0 technologies and solutions" question.

Some of the key points of the conversation that followed are presented below:
- Cost management and creating savings within the businesses are key.

- An alternative to producing "savings" is increasing productivity. Enhancing productivity increases profitability without the need to cut back on staff and other expenses.
- Greater adaptability in response to risks will reduce lead times and increase profitability.

It was expected that reducing costs and increasing potential returns would be the key drivers when making business and strategy decisions concerning the implementation of new technologies. However, it is important to look beyond this. Due to the ageing workforce and risk adverse nature of the sector, there is a focus on the "here and now" rather than looking to the future. It is also worth considering other potential benefits that implementing new and innovative solutions could have. Investing in I4.0 technologies and solutions can boost employee moral which can for example, enhance productivity, marketing opportunities and improve stakeholder perception of the business.

4.4 BARRIERS TO ADOPTING I4.0

As shown in Figure 3, Cost is the major factor considered when implementing I4.0 solutions. The second largest concern revolves around a lack of awareness which is leading to high levels of apprehension in the sector.

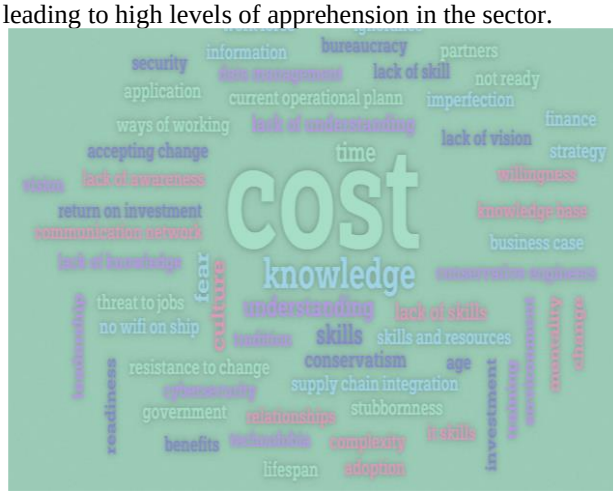

Figure 4: Survey results obtained on "What do you believe are the most significant barriers to I4.0 technologies" question.

Some of the key points of the conversation that followed are presented below:

- Internal cultural change was highlighted by most participants, the aging workforce can be resistant to change, preferring the traditional paper-based systems while the younger generation prefer digital solutions.
- Implementation projects are typically undertaken in a gradual step by step manner, this means that these projects tend to have longer lead times.
- A lack of understanding of the available technology makes carrying out a benefit analysis particularly difficult.
- There is an adversity to standardisation of product offerings - while each project will have unique elements, processes by and large remain the same.
- There is currently limited work being carried out to plan and establish future processes.

While cost is a major concern and is very difficult to remove as a barrier, there are solutions which could be pursued to help alleviate this. As previously stated, greater education and awareness of innovative and disruptive technology and its potential applications could have a dramatic impact. This would allow employees to clearly identify the potential benefits, and if combined with accurate quality control data, would allow for a comprehensive benefit/ROI analysis. By promoting the technologies as a method of assisting employees in their work, the fear and apprehension experienced by many of the workforce could be mitigated. Within the marine industry, particularly with the ageing workforce in the shipbuilding sector, there is a fear that some disruptive and innovative technologies, such as collaborative robots, are being investigated in order to replace the human workforce. This is not necessarily true. Upskilling existing employees and providing high-quality training is a key part of any implementation project to ensure employee engagement.

4.5 CRITICAL I4.0 SKILLS AND ROLES

The results depicted in Figure 5 indicate Data Analysts will be key to the future of the maritime sector. The results also indicate that the specific types of engineering which will be critical are electrical and software.

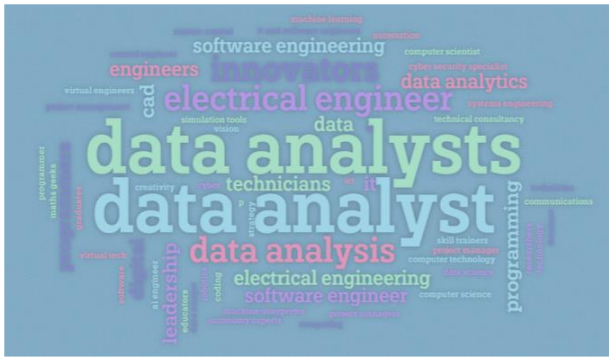

Figure 5: Survey results obtained on "What skills or job roles do you view as being most critical in the next 5 years" question.

Some of the key points of the conversation that followed are presented below:

- Within every group, there were discussions around Data Analysts.
- There was a consensus that the industry has issues retaining Graduate Engineers in the field of engineering - many are being lost to the banking industry.

- It was recognised that some roles may need to be outsourced due to lack of internal skills or that these roles are not required for day-to-day activities.
- Apprenticeships are key in the sector. There should be greater engagement from colleges to upgrade apprenticeship programs in order to align with industry needs.
- It was noted that when considering the future employees of the marine industry, soft skills and personality traits, such as creativeness, ability to problem solve, and drive, are just as important as technical ability.

The industry appears to believe that Data Analysts will be key to the future of the industry. However, it is important to acknowledge that Data Analysts are only as valuable as the data they have access to. Therefore, a more critical challenge in the immediate future is ensuring that accurate and useful data can be captured. This could be achieved through changing employee behaviours and well-established processes. While it is extremely likely that the amount of data available to capture is set to increase dramatically within the next 5 years, most of the analysis could be performed by existing enterprise management software. In order to meet the future needs of the sector, it is recommended that the academic institutions and industry work in tandem more efficiently to identify key skills gaps and develop courses that tackle the issues years before they become a prevalent problem.

4.6 INTERNAL AVAILABILITY OF I4.0 SKILLS

The results depicted in Figure 6 are evenly split between the three options. However, the fact that only one third of the respondents felt that they had the sufficient skills in house to embrace I4.0, highlights a potential and significant skill deficit in the near future.

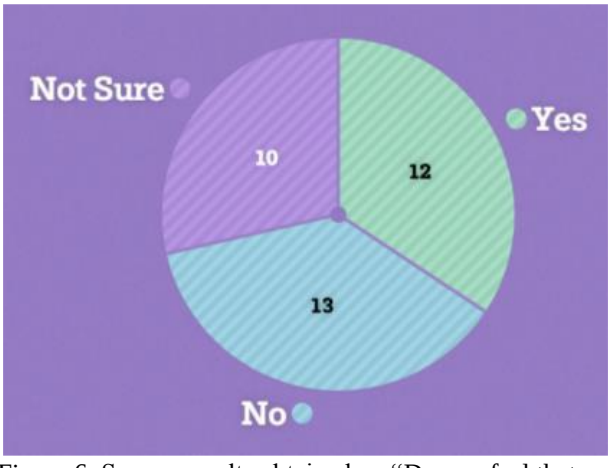

Figure 6: Survey results obtained on "Do you feel that you have the required skills internally to successfully complete your I4.0 journey" question.

Some of the key points of the conversation that followed are presented below:

- It was discovered that leading up to this question, some of the attendee's opinions had changed from "Yes" to "No" due to the day's previous discussions around I4.0 technologies. This indicates that the availability of internal skills is not fully understood or has not been assessed yet.
- As referenced previously in 3.1.3, greater communication between academia and industry was raised as a requirement for success.
- There was a level of uncertainty as to what skills would be required as the technology requirements were not fully understood or defined.
- Attracting skills externally could prove difficult due to high competition in the job market.
- Many felt that a combination of internal skills with fresh, external eyes would be required to improve the businesses.

A program of internal capability assessments could be a useful exercise to perform. It is likely that there will be hidden talents and skills internally which are not currently utilised in the employee's role. This assessment would be a valuable resource in the journey towards implementing new technologies and would allow for the creation of a skills gap analysis which would drive the recruitment focus. The general opinion of the attendees was that the required skills could not be identified without first determining the required technologies to be implemented and the end goal to be achieved. This highlights the fact that a clear technology strategy should be created to provide a detailed implementation roadmap.

4.7 METHODS FOR ACQUIRING NEW SKILLS

Following the results presented in Figure 7, the majority of respondents listed 'Internal Upskilling' as their primary method for acquiring the skills for the future of their business. The remaining five sections also received a significant number of votes, suggesting that a number of different methods will need to be pursued.

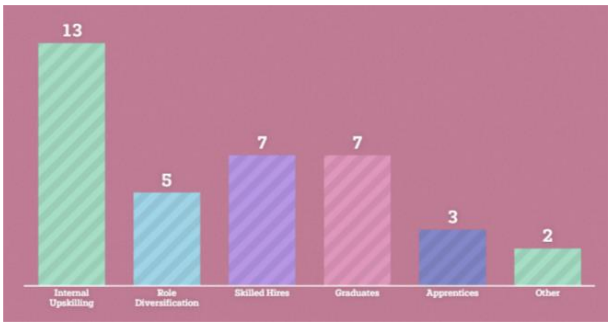

Figure 7: Survey results obtained on "What do you envision being the primary method for acquiring the skills for the future of your business" question.

Some of the key points of the conversation that followed were:

- Expected that a balanced approach will be needed.

- Greater collaboration and potential partnerships could provide the best way forward.
- There was a sense that the industry is not especially good at planning for the future and are instead focussed more on the "here and now".
- Feeling that university and college courses must modernise and involve more industry experience.
- There was recognition that Apprentices tend to stay with the same business for longer than Graduates. It was expressed that Apprentices are often more willing to take time to rise through the business whilst Graduates can be less patient to do so.
- External hires could be an effective way to change the culture within a company.
- Increased options for Apprentices – offer graduate courses upon time served.

The establishment of an industry wide skills network could prove to be an extremely useful resource which would allow for greater collaboration across the sector. This would allow organisations to request personnel, with a specific skill set, from another business on secondment. Whilst in the company the employee would help to upskill existing staff and support the implementation of new technologies. It was also felt that younger people are being prioritised for training, however it is recommended that upskilling and development programs are offered and encouraged to all employees to avoid disengagement with the workforce.

4.8 FUTURE OF THE MARITIME INDUSTRY IN UK WITHOUT MODERNISATION

There was unanimous agreement that the UK marine sector will require modernisation to remain viable and globally competitive.

Some key points of the discussion that ensued were:

- While the industry recognises that it needs to modernise, it is unsure when this can and will start.
- It was recognised that modernisation of the full maritime industry must also include the modernisation of the wider supply chain.
- The sector needs strategic initiatives and major action – prevent more and more talking shops.
- Many attendees acknowledged the fact that in order to compete globally, the UK maritime industry needs to be visionary in the sector and to differentiate through innovative technology and processes.
- It was felt that there is a lack of pride in shipbuilding across the UK and that there are not enough young leaders in the industry to effectively change the current culture.
- The technologies and processes associated with the third industrial revolution have not yet been achieved by most of the marine sector and so attempting to embrace I4.0 is premature.

Therefore, for the UK maritime sector to survive and compete globally, it is essential that the modernisation process begins immediately. This is essential in order to avoid falling further behind other nations who have already begun their I4.0 journey. While it is unlikely that dramatic technological changes will be made immediately, the industry can begin to effectively strategise in a collaborative fashion. This will help drive forward investment by providing a clear scope of activity and outlining the future of the industry.

5. CONCLUSIONS

The survey results described in section 4 provided valuable insights into the current state of the UK Maritime sector and informed those present of potential applications of I4.0 technologies. The survey results and follow-on round table discussions, demonstrated an understanding of Industry 4.0, but a difficulty in how to apply the principles in the Maritime sector. It was widely recognised that Maritime compared to other sectors is falling behind in the uptake of new and innovative technologies. There was also a clear concern over the aging population of the workforce and issues around future skill availability and the appeal of the industry to emerging talent pools.

For the sector to survive it is essential that the industry, Government and academic institutions work together in collaboration. If this does not take place, the likelihood of the industry failing and weakening UK manufacturing becomes increasingly more likely. There is clear indication that the government is determined to maintain Naval capabilities, however the same cannot be said for the maritime sector and its wider supply chain. A summary of the common issues identified across the maritime industry is as follows:

- Cost is the largest motivator in the sector preventing the industry from looking at the bigger picture.
- The industry has a significant age gap in the work force with key skills and knowledge soon to be lost.
- Compared to other industries, such as the automotive and aerospace industry, the maritime sector is falling behind in the implementation of new, innovative and disruptive technologies.
- The UK maritime sector is finding it increasingly difficult to compete on the global market in regard to cost and therefore it needs to compete through innovation
- The industry needs Government support to enhance its infrastructure.
- Communication and collaboration is poor across the industry.
- The culture and leadership across the industry must change drastically in order to successfully implement new technologies, skills and processes.

For the UK Maritime sector to maintain and improve its national and global position, the transition towards I4.0 principles and methods of manufacturing must start now. A clear holistic strategy must be formulated for each company, as well as internal business strategies for the adoption of technology, skills and required cultural changes to ensure the success of implementation. Key aspects that should be considered while designing this strategy are:

- Industry, Government and academic institutions must communicate and collaborate more effectively
- The industry must provide a unified voice and lobby the Government for support and present a clear, well established strategy to drive investment and the creation of a Maritime Catapult centre.
- The industry must now begin to strategise how it will modernise both internally and as a collective.
- College and University courses need to modernise to meet the current needs of the industry and attract the young workforce.
- The industry needs to envisage the future of the marine sector and recognise that the initial expenditure for new technology will reap benefits over time.
- The culture and leadership must develop and learn from other industries already on this journey via greater cross industry collaboration and extensive benchmarking activities.

6. ACKNOWLEDGEMENTS

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